

## MP64E M-663 Linear Positioning Stage User Manual

Version: 1.6.0

Date: 15.12.2010



**This document describes the following product(s):**

- **M-663.465**  
PIline® Translation Stage,  
19 mm, Linear Encoder, 0.1  $\mu$ m  
Resolution
- **M-663.Y65**  
PIline® Translation Stage,  
19 mm, Linear Encoder, 0.1  $\mu$ m  
Resolution, turned cable outlet,  
XY Mountable



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The products described in this document are in part protected by the following patents:

US Pat. No. 6,765,335

German Patent No. 10154526

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First printing: 15.12.2010

Document number: MP64E CBo, Release 1.6.0

Subject to change without notice. This manual is superseded by any new release. The latest release is available for download on our website (<http://www.pi.ws>).

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# 1 About this Document

## In this Chapter

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## 1.1 Goal and Target Audience of this Manual

This manual contains information on the prescribed use of the M-663.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

For updated releases of this user manual, or if you have any questions, contact our customer service department (see p. 37).

## 1.2 Symbols and Typographic Conventions

The symbols and typographic conventions used in this manual have the following meanings:

### ***DANGER***



#### **Imminently hazardous situation**

If not avoided, the hazardous situation will result in death or serious injury.

- Action to be taken to avoid the hazard

### ***NOTICE***



#### **Hazardous situation**

If not avoided, the hazardous situation will result in damage to the equipment.

- Action to be taken to avoid the hazard

**INFORMATION**

Information to facilitate operation and handling, tips and tricks, and so on.

| Symbol   | Meaning   |
|----------|---|
| 1.<br>2. | Action consisting of several steps whose sequential order must be observed.     |
| ➤        | Action consisting of one or several steps whose sequential order is irrelevant. |
| ▪        | List item   |
| see p. 5 | Cross-reference to page 5.  |

## 1.3 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

For the latest versions of the user manuals contact our customer service department (see p. 37).

| Device                  | Document   |
|-------------------------|--|
| C-185 drive electronics | MS137E User Manual C-185 Analog Drive Electronics  |
| C-867 controller        | MS185E User Manual C-867.160 PLine® Controller<br>MS189E User Manual C-867.260 PLine® Controller |

## 2 Safety

### In this Chapter

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### 2.1 Prescribed Use

The M-663 is a laboratory device as defined by DIN EN 61010. It is intended to be used in interior spaces and in an environment which is free of dirt, oil and lubricants.

Based on its design and realization, the M-663 is intended for single-axis positioning, adjusting and shifting of loads at various velocities.

The prescribed use of the M-663 is only possible in combination with suitable electronics. The following options exist:

- Drive electronics and controller with suitable software
- Combination device with suitable software

The electronics is not included in the scope of delivery of the M-663.

The electronics must provide the operating voltage required by the piezomotor(s). To ensure proper performance of the servo-control system, the electronics must be able to read out and further process the signals from the reference switch as well as the ones from the incremental position encoder.

### 2.2 General Safety Instructions

The M-663 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the M-663.

- Only use the M-663 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the M-663.

### Organizational Measures

#### User Manual

- Always keep this user manual next to the M-663 when using the M-663. If the user manual is lost or damaged, contact our customer service department (see p. 37).
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- Only use the device on the basis of the complete user manual. If your user manual is incomplete and is therefore missing important information, serious or fatal injury as well as property damage can result.
- Only install and operate the M-663 after having read and understood this user manual.

#### Personnel Qualification

Only authorized and qualified personnel must install, operate, maintain and clean the M-663.

### 2.2.1 Safety Measures During Installation

The M-663 can be damaged by screws that are too long and parts that are wrongly mounted.

- When mounting the M-663 on a surface, make sure that the mounting screws do not interfere with the motion of the stage. The screw heads must not protrude from the counter-sunk holes.
- Note the depth of the mounting holes in the moving platform.
- Only use screws of the correct length for the respective mounting holes.
- Only mount the M-663 and the loads on the M-663 using the mounting fixtures (holes) intended for this purpose.

The M-663 heats up during operation. High temperatures can influence your application.



- Install the M-663 so that your application is not affected by the dissipating heat.

Cable extensions can affect the performance of the M-663 and damage the electronics.

- Only use genuine PI parts to connect the M-663 to the electronics.
- Do not use cable extensions. If you need longer cables, use the M-663.AB adapter box and an extension cable from PI (see p. 10).
- Avoid shorting the piezo voltage lines since this can damage the electronics.

### **2.2.2 Safety Measures During Start-Up**

- Do not start up the M-663 until it is fully mounted and connected.

Your application can be damaged by uncontrolled vibration of the M-663. A typical sign of vibration is noise during the operation of the M-663.

- Immediately switch off the servo-control system of the affected stage axes.
- Check the settings of the servo control parameters.

Moving parts attached to devices with motorized stages can accelerate rapidly and generate high forces which can cause injury or property damage.

When connecting the stage to the controller for the first time, the stage can perform an unintentional motion. Defective software or wrong operation of the software can also result in unintentional motions.

- Do not place any objects in areas where they can get caught by moving parts.

The motion of the moving platform is aborted by the hard stop. To prevent damage to, or considerable wear on the M-663, you must avoid high acceleration as well as the collision of the moving platform with the hard stop.

- Only command target positions that are located within the travel range.
- Ensure that the platform approaches the end of the travel range at low velocity.

- Ensure that the moving platform does neither abruptly stop at the end of the travel range nor attempt to continue moving.
- Determine the maximum velocity for your application.

### 2.2.3 Safety Measures During Operation

- If noise is generated during operation of the M-663, check the settings of the servo control parameters of your controller.

Highest dynamic force and holding force are achieved at maximum level (100 %) of the control signal. However during continuous operation the motor/drive can overheat at this input level.

- During continuous operation at room temperature, do not exceed 90 % of the control signal level.
- For continuous operation at other temperatures, refer to the maximum allowable duty cycle vs. ambient temperature (see p. 42).

### 2.2.4 Safety Measures During Maintenance

The M-663 is precisely aligned.

- Do not loosen any sealed screws.

Dirt, oil, lubricants and condensation will render the motor/drive inoperable.

- Ensure that the piezomotor of the M-663 does not come into contact with lubricants.
- Keep the M-663 free from dirt and condensation.

## **3 Product Description**

### **In this Chapter**

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### **3.1 Features and Applications**

M-663 linear positioning stages make use of PLine® ultrasonic piezo linear motors enabling a compact design and low profile.

An integrated linear encoder offers precision position control with 0.1 µm resolution.

The PLine® linear motor provides push forces to 2 N and a maximum velocity of up to 400 mm/s over a 19 mm travel range.

The stages can be combined to XY systems for applications requiring a multi-axis alignment (see p. 20).

Vacuum-compatible versions of the M-663 are available on request.

## 3.2 Model Overview

Two standard versions of the M-663 are available. They differ in the cable exit:



Figure 1: M-663 model overview: M-663.465 (front) and M-663.Y65 (back)

| M-663.465  | M-663.Y65  |
|--|--|
| PILine® Translation Stage, 19 mm,<br>Linear Encoder, 0.1 µm Resolution | PILine® Translation Stage, 19 mm,<br>Linear Encoder, 0.1 µm Resolution,<br>turned cable outlet, XY Mountable |

### 3.3 Product View

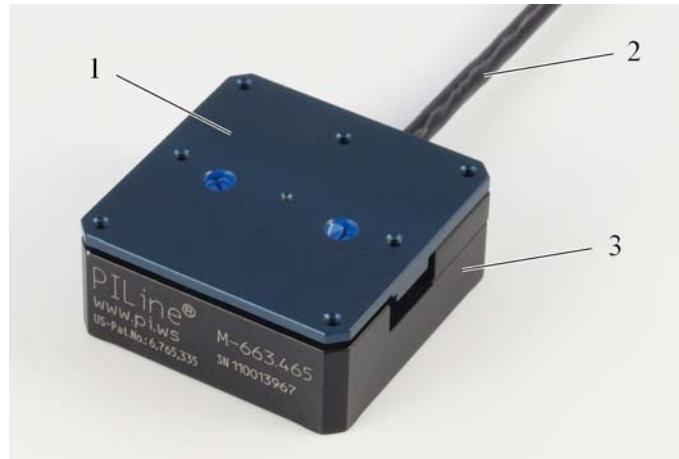


Figure 2: M-663 product view

- 1 Moving platform
- 2 Connection cable to the electronics
- 3 Base body

### 3.4 Scope of Delivery

| Order Number                 | Item(s)   |
|------------------------------|---|
| M-663.465<br>or<br>M-663.Y65 | PILine® Translation Stage, 19 mm, Linear Encoder, 0.1 µm Resolution<br><br>PILine® Translation Stage, 19 mm, Linear Encoder, 0.1 µm Resolution, turned cable outlet, XY Mountable |
| 000011207                    | Screw set: <ul style="list-style-type: none"> <li>▪ 4 hex-head cap screws M1.6x5 ISO 4762</li> <li>▪ 1 Allen wrench</li> </ul>  |
| MP64E                        | User manual (this document) in printed form   |

## 3.5 Accessories

| Order Number                                       | Description  |
|--|--|
| M-663.AV1  | <ul style="list-style-type: none"> <li>▪ Mounting bracket for vertical mounting, including screw set no. 000031517: <ul style="list-style-type: none"> <li>– 6 hex-head cap screws M1.6x4</li> <li>– 3 hex-head cap screws M1.6x6</li> <li>– 3 hex-head cap screws M2x6</li> </ul> </li> </ul> |
| M-663.AB   | <ul style="list-style-type: none"> <li>▪ Adapter Box, MDR to 15-pin Sub-D, for PLine® Stages with Long Cables</li> <li>▪ Technical Note M663T0015 for adapter box</li> </ul>   |
| Extension cable for use with adapter box M-663.AB: |  |
| M-663.A01  | Extension Cable for PLine®, MDR to 15-pin Sub-D, 1 m   |
| M-663.A03  | Extension Cable for PLine®, MDR to 15-pin Sub-D, 3 m   |
| M-663.A05  | Extension Cable for PLine®, MDR to 15-pin Sub-D, 5 m   |
| M-663.A10  | Extension Cable for PLine®, MDR to 15-pin Sub-D, 10 m  |

To order, contact our customer service department (see p. 37).

## 3.6 Technical Features

### 3.6.1 Linear Encoder

The M-663 is equipped with an optical linear encoder featuring 0.1 µm resolution.

Linear optical encoders measure the actual position directly (direct metrology).

Therefore, errors occurring in the drive, such as non-linearity, backlash or elastic deformations cannot influence the measurement of the position.

### **3.6.2 Reference Switch**

The M-663 is equipped with a direction-sensing reference switch, which is located at about the midpoint of the travel range. This sensor provides a TTL signal indicating whether the stage is to the positive or negative side of the reference switch.

The rising or falling edge of this signal can be used to indicate a known reference position. The difference in the reference points when approached from the positive or the negative side is about 0.2 mm to 0.4 mm.

See the controller user manual and/or associated software manuals for the commands which make use of the reference signal.

For further details, refer to the "Specifications" section (see p. 39).





## **4 Unpacking**

1. Unpack the M-663 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials. You can use it to re-package the M-663 in the event the product needs to be returned.



## 5 Installation

### In this Chapter

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### 5.1 General Notes on Installation

#### NOTICE



##### **Lubricants, dirt, condensation!**

Dirt, oil, lubricants and condensation will render the motor/drive inoperable.

- Ensure that the piezomotor of the M-663 does not come into contact with lubricants.
- Keep the M-663 free from dirt and condensation.

#### NOTICE



##### **Unsuitable or extended cables!**

Unsuitable or extended cables can damage the electronics and can affect the performance of the M-663.

- Only use cables provided by PI for connecting the M-663 to the electronics.
- Do not use cable extensions. If you need longer cables, use the M-663.AB adapter box and an extension cable from PI (see p. 10).

For more information about operational conditions, refer to the "Drive Performance" section (see p. 41).

## 5.2 Mounting the Stage on a Surface

### NOTICE

**Protruding screw heads!**

Protruding screw heads can damage the M-663.

- Ensure that the screws are completely fastened and that the screw heads do not protrude from the counter-sunk holes so that they do not interfere with the stage motion.

### NOTICE

**Warping of the base body!**

Incorrect mounting can warp the base body. Warping of the base body will increase wear and reduce accuracy.

- Mount the M-663 on a flat surface. The recommended evenness for the surface is 10 µm.

### NOTICE

**Use at least three screws to mount your stage!**

To ensure that the M-663 is securely mounted, we recommend that you use at least three screws.

- Use two screws to mount the M-663 at the top side and at least one screw to mount it at the bottom side.



Figure 3: Motion directions of the M-663.465 (left) and M-663.Y65 (right)

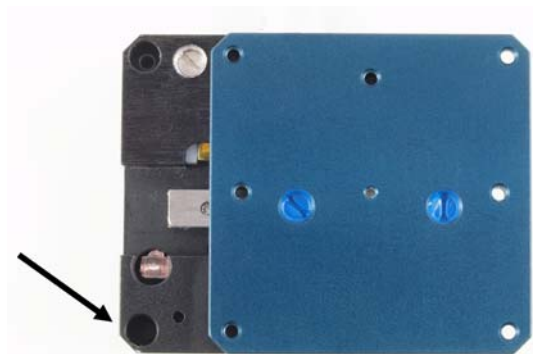


Figure 4: M-663, top view: Two of the three counter-sunk holes in the base body are visible. The deeper hole must be used for mounting the stage from the top side (see arrow).



Figure 5: M-663, bottom view, threaded holes for mounting the stage from the bottom side (see arrows)

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (see p. 15).

### Tools and Accessories

- 2 included M1.6x5 screws and Allen wrench (see p. 9)
- If you also want to mount the stage at the bottom side:  
1 or 2 M2 screws of a suitable length and a suitable wrench (not included)

### Mounting the M-663 on a Surface

1. Displace the moving platform of the M-663 manually to make two of the three counter-sunk holes in the base body accessible (see top view).
2. Mount the stage with one of the included screws in the deeper hole (see arrow in the top view).
3. Ensure that the screw head does not protrude from the counter-sunk hole.
4. Move the platform manually to the other side so that only one counter-sunk hole in the base body is accessible.
5. Mount the stage with one of the included screws.
6. Ensure that the screw head does not protrude from the counter-sunk hole.
7. For secure attachment:  
Mount the stage at the bottom side using at least one of the threaded holes in the base body (see arrows in the bottom view) and an M2 screw of a suitable length.

## 5.3 Affixing the Load

### NOTICE



#### Screws that are too long!

The M-663 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the moving platform (see p. 44).
- Only use screws of the correct length for the respective mounting holes.

### INFORMATION

If the M-663 is mounted vertically, the maximum load is 50 g. For loads higher than 50 g, you will need a mechanism for counterbalancing gravity. In this case, contact our customer service department (see p. 37).

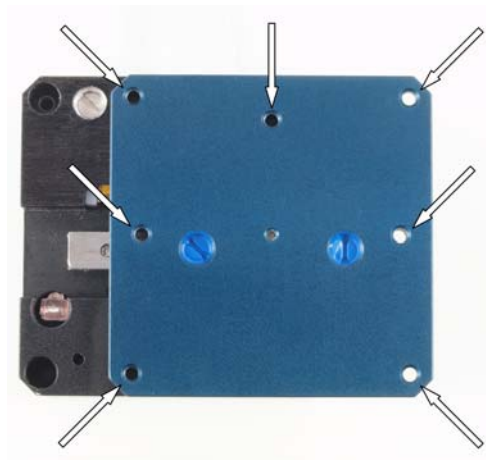


Figure 6: M-663, threaded holes for affixing a load (see arrows)

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (see p. 15).

### Tools and Accessories

- M1.6 screws of a suitable length (see p. 44)
- Suitable wrench

### Affixing the Load

1. Choose the mounting position so that the seven M1.6 threaded holes in the moving platform (see arrows in the figure) can be used for affixing the load.
2. Affix the load to the moving platform using the screws.

## 5.4 Mounting Stacked Systems

### 5.4.1 Stacking an XY System

You can stack two linear positioning stages to form an XY systems as shown below:



Figure 7: M-663.Y65 (top) and M-663.465 (bottom) as stacked XY system

For stacked XY systems, we recommend that you use an M-663.465 for the X-axis and an M-663.Y65 for the Y-axis. In this case, the cable exits of both stages are on the same side.



### NOTICE



#### Screws that are too long!

The M-663 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the moving platform (see p. 44).
- Only use screws of the correct length for the respective mounting holes.

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (see p. 15).

### Tools and Accessories for stacking two M-663 stages

- 2 included M1.6x5 screws and Allen wrench (see p. 9)

### Stacking an M-663 on an M-663

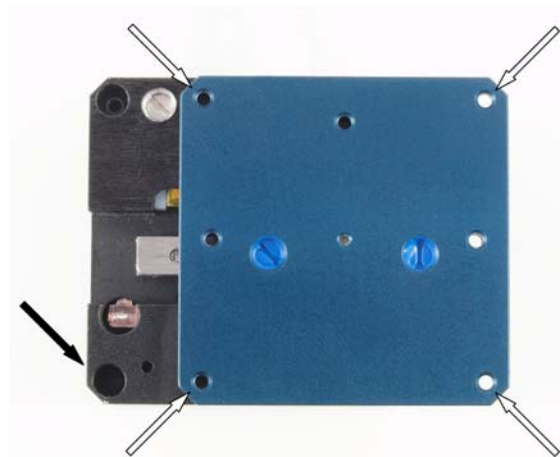


Figure 8: Mounting holes in the moving platform and the base body of the M-663 (see arrows)

1. Rotate the upper M-663 by 90° and position it on the lower M-663. It is possible to rotate the upper stage again by 180° for a different orientation of its cable exit.
2. Displace the moving platform of the M-663 manually to make two of the three counter-sunk holes in the base body accessible (see figure).

3. Mount the upper M-663 with one of the included screws on the lower M-663. To do this, use the deeper hole in the base body of the upper M-663 (see the black arrow in the figure) and one of the threaded holes in the platform of the lower M-663 (see the white arrows in the figure).
4. Ensure that the screw head does not protrude from the counter-sunk hole.
5. Move the platform of the upper M-663 manually so that only one counter-sunk hole in the base body is accessible.
6. Mount the upper M-663 with one of the included screws on the moving platform of the lower M-663.
7. Ensure that the screw head does not protrude from the counter-sunk hole.

### 5.4.2 Stacking a Z System

You can form a Z system (XZ or XYZ combination) by mounting one M-663 on another M-663 using a mounting bracket. You can use both the M-663.465 and the M-663.Y65 to form a Z system.

#### NOTICE



##### **Screws that are too long!**

The M-663 can be damaged by screws that are too long.

- Note the depth of the mounting holes in the moving platform (see p. 44).
- Only use screws of the correct length for the respective mounting holes.

#### INFORMATION

The mounting bracket can also be mounted on the M-663 in a 180° rotated position.

- Mount the load centrically.

#### INFORMATION

If the M-663 is mounted vertically, the maximum load is 50 g. For loads higher than 50 g, you will need a mechanism for counterbalancing gravity. In this case, contact our customer service department (see p. 37).

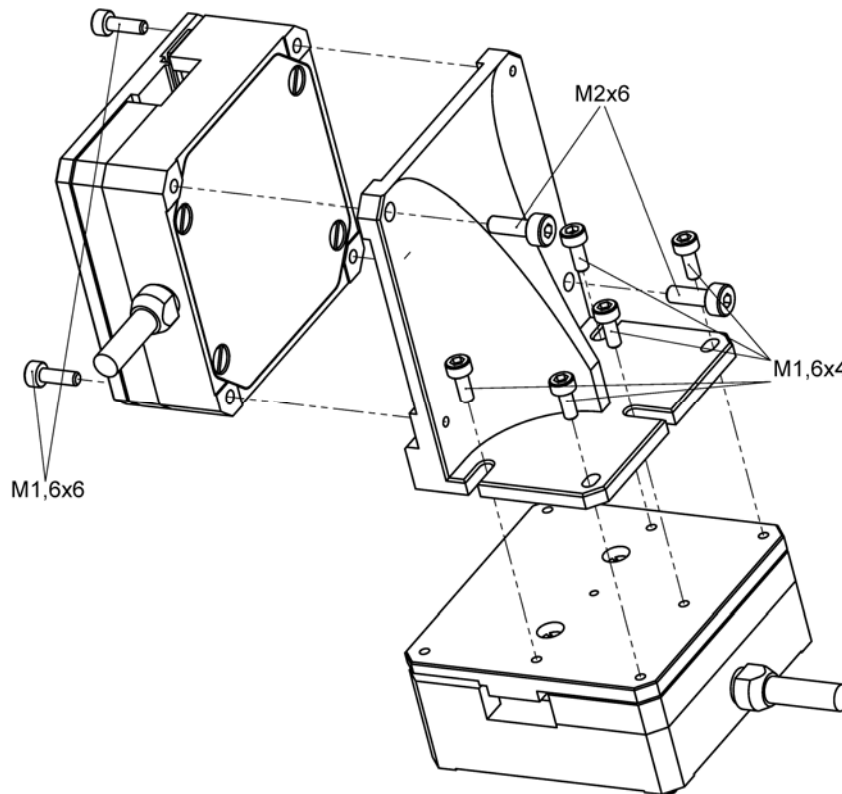


Figure 9: Z system consisting of two M-663.465 stages and an M-663.AV1 mounting bracket

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (see p. 15).

### Tools and Accessories

- M-663.AV1 mounting bracket and included screws (see p. 10)

### Stacking a Z System

1. Mount the M-663.AV1 mounting bracket on the lower M-663. Use at least four M1.6x4 screws for this purpose.
2. Mount the upper M-663 to the mounting bracket. Use two M1.6x6 and two M2x6 screws for this purpose. Proceed as when mounting the M-663 to a surface (see p. 16).



## 6 Start-Up

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### 6.1 General Notes on Start-Up

#### **DANGER**



#### **High voltage and residual charge on piezo actuators!**

PILine®Motors are driven by piezo actuators. After disconnecting the electronics, the piezo actuator can stay charged for several hours. Temperature changes can also induce charges in the piezo actuators. Touching the piezo actuators can result in serious injury or death.

- **Do not** disassemble the M-663.

#### **NOTICE**



#### **Uncontrolled vibration!**

Your system can be damaged by uncontrolled vibration of the M-663. If noise is generated during operation of the M-663, do the following:

- Immediately switch off the servo-control system of the affected stage axes.
- Check the settings of the servo control parameters.

**NOTICE****Collision of the moving platform with the hard stop!**

The motion of the moving platform is aborted by the hard stop. To prevent damage to, or considerable wear on the M-663, you must avoid high acceleration as well as the collision of the moving platform with the hard stop.

- Only command target positions that are located within the travel range.
- Ensure that the platform approaches the end of the travel range at low velocity.
- Ensure that the moving platform does neither abruptly stop at the end of the travel range nor attempt to continue moving.
- Determine the maximum velocity for your application.



Figure 10: Motion directions of the M-663.465 (left) and M-663.Y65 (right)

**INFORMATION**

To obtain best position repeatability, we recommend that you always approach the reference switch from the same side.

The start-up procedure for the M-663 depends on the hardware you are using (see p. 47). In this user manual, the following two alternatives are described:

- C-867 piezomotor controller/driver from PI (see p. 27)
- C-185 analog drive electronics from PI with a suitable controller (see p. 28)

## 6.2 Start Up the M-663 with the C-867 Controller

### **INFORMATION**

Irrespective of the number of axes to be connected, the software needs to be installed only once on the PC which is to be used for commanding the mechanics (see C-867 User Manual).

### **Prerequisites**

- ✓ You have read and understood the General Notes on Start-Up (see p. 25).
- ✓ The M-663 has been correctly installed (see p. 15).
- ✓ The C-867 piezomotor controller/driver and the required software have been installed. All connections with the C-867 have been established (see C-867 User Manual).

### **Starting Up the M-663 with the C-867 Controller**

1. Start up the stage axis (see C-867 User Manual).  
The start-up procedure involves the following steps:
  - Selecting the stage type
  - Referencing the axis
  - Commanding motion in closed-loop operation

The description in the C-867 User Manual assumes that you perform these steps using PIMikroMove.
2. Optionally:  
For optimum performance of the stage axis, it may be necessary to adjust the servo control parameters of C-867 (e. g. P-term, I-term, D-term).  
Save the new parameter values for future use.
3. Command a few motion cycles for testing and run-in of the mechanical system (<50 % duty cycle).

After run-in, the M-663 will generate its maximum dynamic force.

## 6.3 Start Up the M-663 with the C-185 Drive Electronics

### NOTICE



#### Replacement of fine-tuned system components!

The C-185 drive electronics is fine-tuned to the M-663 before delivery for optimum system performance. Replacing the drive electronics or the M-663 can impair the operation of the M-663.

- **Do not** exchange the drive electronics or the M-663 of a fine-tuned system.
- If you must replace parts of your system, the fine-tuning procedure must be repeated (see the frequency tuning description in the user manual of the drive electronics).
- With multi-axis systems respect also the assignment of the axes to the drive electronics. This assignment is indicated by labels on the devices.

### Prerequisites

- ✓ You have read and understood the General Notes on Start-Up (see p. 25).
- ✓ The M-663 has been correctly installed (see p. 15).
- ✓ You have a suitable controller with the following features:
  - The controller provides the control signal for the C-185 drive electronics.
  - The controller can read out and process the signals from the reference switch and the incremental position encoder.
- ✓ You have read and understood the user manual of the controller.
- ✓ You have prepared the controller for operation.

### Starting Up the M-663 with the C-185 Drive Electronics and a Suitable Controller

1. Connect the stage axis to the "Closed-loop piezomotor" socket of the C-185 drive electronics which was tuned with this axis (see labels on the electronics and the connectors).
2. Connect the drive electronics to the controller and to the power supply (see C-185 User Manual).



3. Configure and move the axis according to the description in the user manual of the controller and/or the manual of any software which came with the controller.  
If it should be necessary to set stage-dependent parameters, you can use the values from the table in the "Operating Parameters" section (see p. 31).
4. Command a few motion cycles for testing and run-in of the mechanical system (<50 % duty cycle).

After run-in, the M-663 will generate its maximum dynamic force.



## 7 Operation

### In this Chapter

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### 7.1 General Notes on Operation

#### NOTICE



#### Heating up of the M-663 during operation!

The heat produced during operation might affect your application.

- Install the M-663 so that your application is not affected by the dissipating heat.

#### INFORMATION

If unusual noise is generated during the operation of the M-663, check the settings of the servo control parameters of your controller.

For more information about operational conditions, refer to the "Drive Performance" section (see p. 41).

### 7.2 Operating Parameters

For the C-867 controller from PI, the operating parameters are included in the software that comes with the device.

If it should be necessary to set specific parameters for another controller, you can use the following values:

| Stage-dependent Parameters      | Value                    |             |
|---------------------------------|--------------------------|-------------|
| Encoder resolution              | 10 counts/ $\mu\text{m}$ |             |
| P-term*                         | 20                       | 1100 V/mm** |
| I-term*                         | 50                       | 1024000 s** |
| D-term*                         | 60                       | 0.006 s**   |
| Motor offset positive/negative* | 1.5 V                    |             |
| Velocity*                       | 400 mm/s                 |             |
| Acceleration*                   | 2000 mm/s <sup>2</sup>   |             |

\*Recommended initial value. The optimum value depends on the technical requirements, e.g. load, of your application.

\*\*Depending on the controller and/or control algorithm you use, these values have to be converted.

#### NOTICE



##### Overheating during continuous operation!

Highest dynamic force and holding force are achieved at maximum level (100 %) of the control signal. However, during continuous operation the M-663 can overheat at this input level.

- During continuous operation at room temperature, do not exceed 90 % of the control signal level.
- For continuous operation at other temperatures, refer to the maximum allowable duty cycle (see p. 42).

## 7.3 Short Operating Time

The M-663 will not immediately achieve its maximum dynamic and holding force when operated after a rest period or with low duty cycle. This behavior results from the contamination of the M-663 components which occurs even during a short downtime.

## 8 Maintenance

### NOTICE



#### Damage due to improper maintenance!

Improper maintenance can result in misalignment and malfunction of the M-663.

- Do not loosen any sealed screws.
- Ensure that the piezomotor of the stage does not come into contact with lubricants.

Depending on the operational conditions and the period of use of the M-663, the following maintenance measures are required:

### Maintenance Run

The maintenance run is performed to redistribute the existing lubricant on the guidings of the stage.

- To evenly distribute the existing lubricant on the stage guidings, perform a maintenance run across the entire travel range after 500 hours of operation, or after 1 year at the latest.
- If you operate your stage continuously on a small travel range (<20 % of the entire travel range), perform a maintenance run every 5000 motion cycles across the entire travel range.

### Lubrication

Under laboratory conditions, the guidings of the stage need to be lubricated in exceptional cases only. For continuous industrial use the lubrication intervals must be defined individually.

- Do not lubricate the guidings of the M-663 until after consultation with our customer service department (see p. 37).
- To lubricate the guidings, follow the instructions given in the maintenance manual which you can obtain from our customer service department.

- Ensure that the piezomotor of the stage does not come into contact with lubricants.

## 9 Troubleshooting

| Problem   | Possible Causes  | Solution  |
|---|--|---|
| Noise during operation                          | Uncontrolled vibration of the M-663  | <ul style="list-style-type: none"> <li>➤ Immediately switch off the servo-control system of the affected stage axes.</li> <li>➤ Check the settings of the servo control parameters.</li> </ul>  |
| Increased wear<br>Reduced accuracy              | Warped base body   | <ul style="list-style-type: none"> <li>➤ Mount the M-663 on a flat surface. The recommended evenness for the surface is 10 µm.</li> </ul>   |
| Functional impairment after system modification | <ul style="list-style-type: none"> <li>▪ C-185 drive electronics has been replaced</li> <li>▪ M-663 has been replaced</li> </ul> | <ul style="list-style-type: none"> <li>➤ Repeat the fine-tuning procedure for the C-185 drive electronics and the M-663 (see the frequency tuning description in the user manual of the drive electronics).</li> <li>➤ With multi-axis systems respect the assignment of axes to the drive electronics. This assignment is indicated by labels on the devices.</li> </ul> |
| No or limited vertical motion                   | <ul style="list-style-type: none"> <li>▪ Load too high</li> </ul>  | <ul style="list-style-type: none"> <li>➤ Reduce the load to a maximum of 50 g.</li> <li>➤ For loads higher than 50 g, you will need a mechanism for counterbalancing gravity. In this case, contact our customer service department (see p. 37).</li> </ul>   |

If the problem that occurred with your system is not listed in the table above or it cannot be solved as described, contact our customer service department (see p. 37).





## 10 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail ([info@pi.ws](mailto:info@pi.ws)).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Current firmware version of the controller (if present)
- Software version of driver or host software (if present)
- Operating system on host PC (if present)

The latest versions of the relevant user manuals for your system are available for download on our website (<http://www.pi.ws>).



# 11 Technical Data

## In this Chapter

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| Dimensions.....                                 | 44 |
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| Suitable Drive Electronics and Controllers..... | 47 |

## 11.1 Specifications

|                                | <b>M-663.465 / M-663.Y65</b>       | <b>Units</b> | <b>Tolerance</b> |
|--------------------------------|------------------------------------|--------------|------------------|
| Active axes                    | X                                  |              |                  |
| <b>Motion and positioning</b>  |                                    |              |                  |
| Travel range                   | 19                                 | mm           |                  |
| Integrated sensor              | Linear encoder                     |              |                  |
| Sensor resolution              | 0.1                                | µm           |                  |
| Min. incremental motion        | 0.3                                | µm           | typ.             |
| Bidirectional repeatability    | ±0.3                               | µm           | typ.             |
| Unidirectional repeatability   | 0.2                                | µm           | typ.             |
| Pitch                          | ±300                               | µrad         | typ.             |
| Yaw                            | ±300                               | µrad         | typ.             |
| Velocity                       | 400                                | mm/s         | max.             |
| Reference switch repeatability | 1                                  | µm           | typ.             |
| <b>Mechanical properties</b>   |                                    |              |                  |
| Load                           | 5                                  | N            | max.             |
| Push/pull force                | 2                                  | N            | max.             |
| Holding force                  | 2                                  | N            | max.             |
| <b>Drive properties</b>        |                                    |              |                  |
| Motor type                     | P-661 PLine® ultrasonic piezomotor |              |                  |
| Operating voltage              | 120 (peak-peak)*<br>42 (RMS)*      | V            |                  |
| Electrical power               | 5**                                | W            | nominal          |
| Current                        | 400**                              | mA           |                  |
| Reference switch               | Optical                            |              |                  |
| <b>Miscellaneous</b>           |                                    |              |                  |
| Operating temperature range    | -20 to +50                         | °C           |                  |
| Material                       | Al (anodized)                      |              |                  |
| Dimensions                     | 35 x 35 x 15                       | mm           |                  |
| Mass                           | 40                                 | g            | ±5 %             |

|                               | <b>M-663.465 / M-663.Y65</b>                           | <b>Units</b> | <b>Tolerance</b> |
|-------------------------------|--|--------------|------------------|
| Cable length                  | 1.5  | m            | ±10 mm           |
| Connector                     | MDR, 14-pin  |              |                  |
| Recommended controller/driver | C-867 controller/driver<br>C-185.161 drive electronics |              |                  |

\* Power for the motor is supplied by the drive electronics, which runs on 12 V DC, or by the controller (24 V).

\*\* For drive electronics

### Reference Switch Specifications

|                |  |
|----------------|--|
| Type           | Optical sensor   |
| Supply voltage | +5 V/GND, supplied via the motor connector   |
| Signal output  | TTL level  |
| Signal logic   | Direction sensing by means of different signal levels on the left and right side of the reference switch: The signal level changes from 0 to +5 V when the reference switch is passed. Direction recognition by means of different signal levels on the left and right side of the reference switch: The signal level changes from 0 to +5V when the reference switch is passed. |

## 11.2 Drive Performance

### 11.2.1 Velocity and Dynamic Force

To estimate the M-663 performance at different levels of the control signal, refer to the following graph.

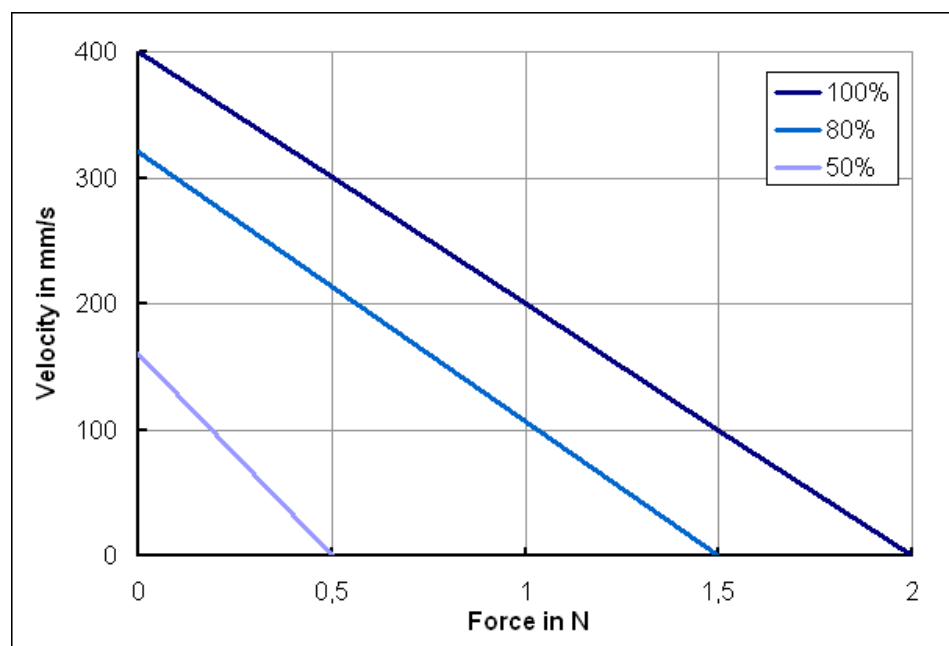


Figure 11: Velocity of the M-663 vs. dynamic force (push/pull force) at various levels of the control signal

### 11.2.2 Impact of Ambient Temperature and Downtime

To protect your equipment against damage, refer to the following graphs.

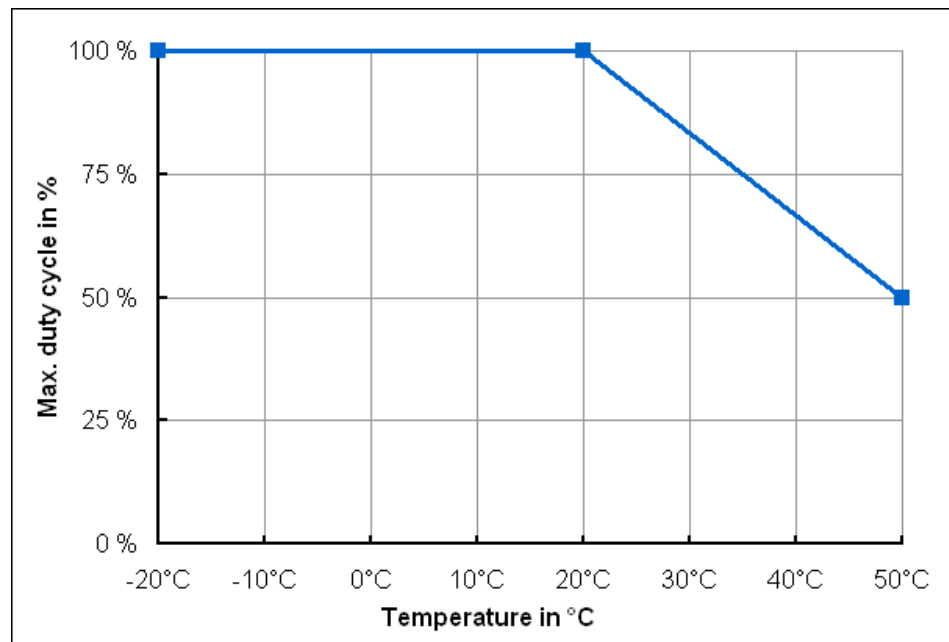


Figure 12: Maximum duty cycle vs. ambient temperature at maximum level of the control signal

#### INFORMATION

In closed-loop operation the control signal level depends on the given velocity.

- To avoid overheating, fine-tune the duty cycle, ambient temperature and velocity to each other.

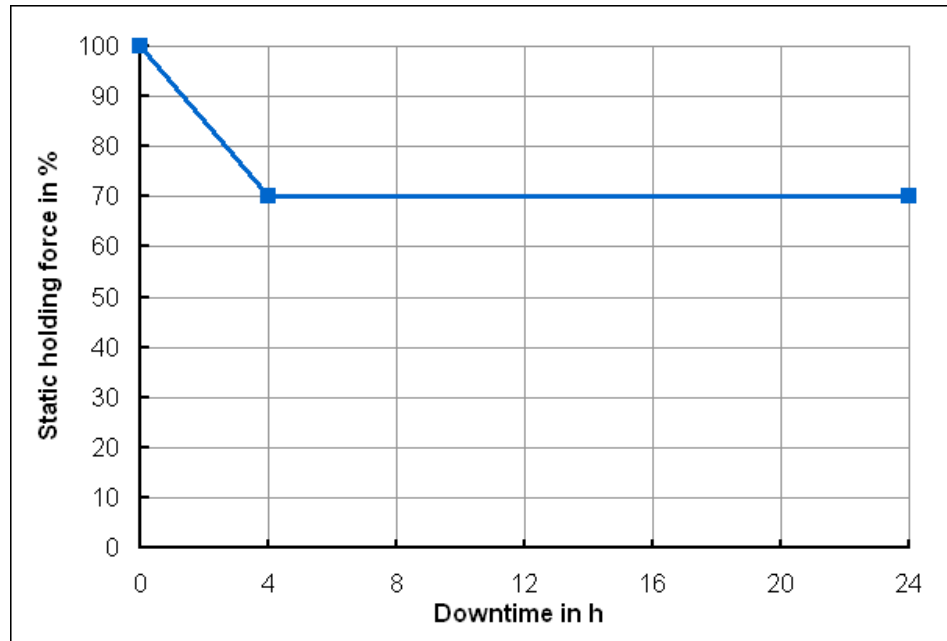


Figure 13: Static holding force depending on the downtime of the motor

## 11.3 Dimensions

Dimensions in mm. Note that the decimal places are separated by commas in the drawings.

Standard tolerance according to DIN ISO 2768 - f - H

Roughness Ra 1.6

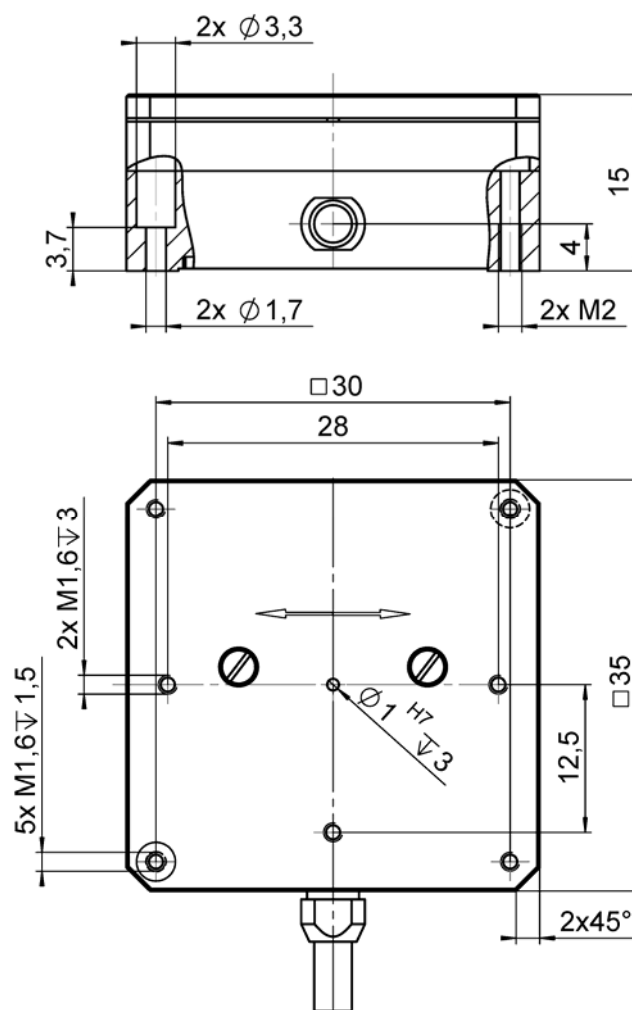


Figure 14: M-663.465



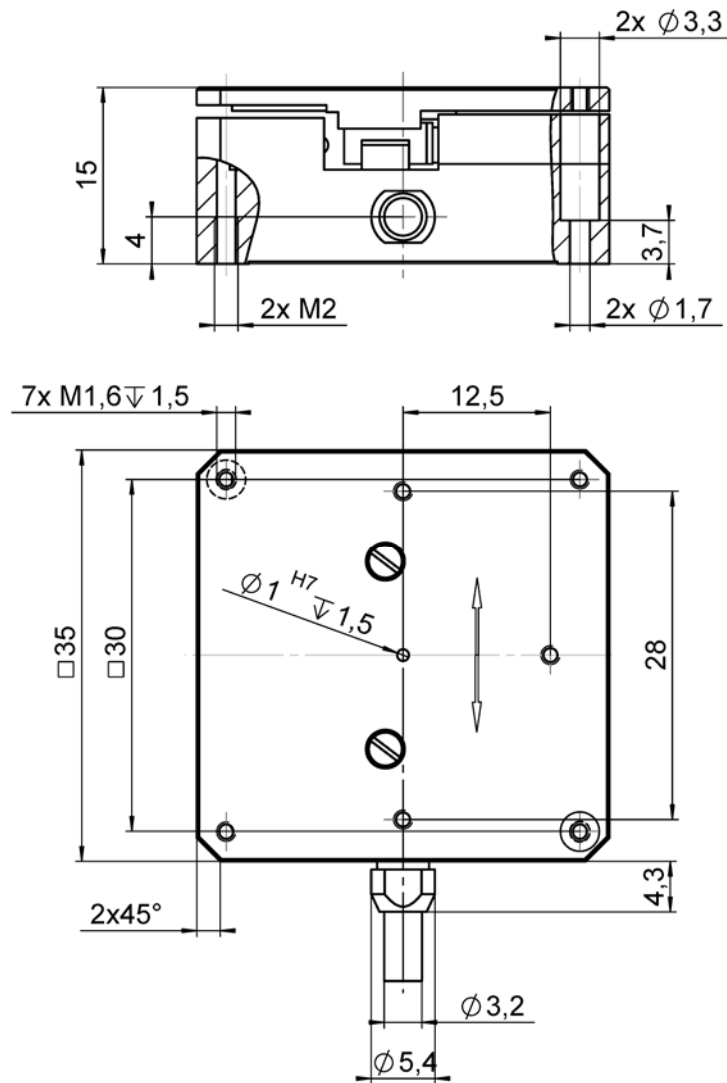


Figure 15: M-663.Y65

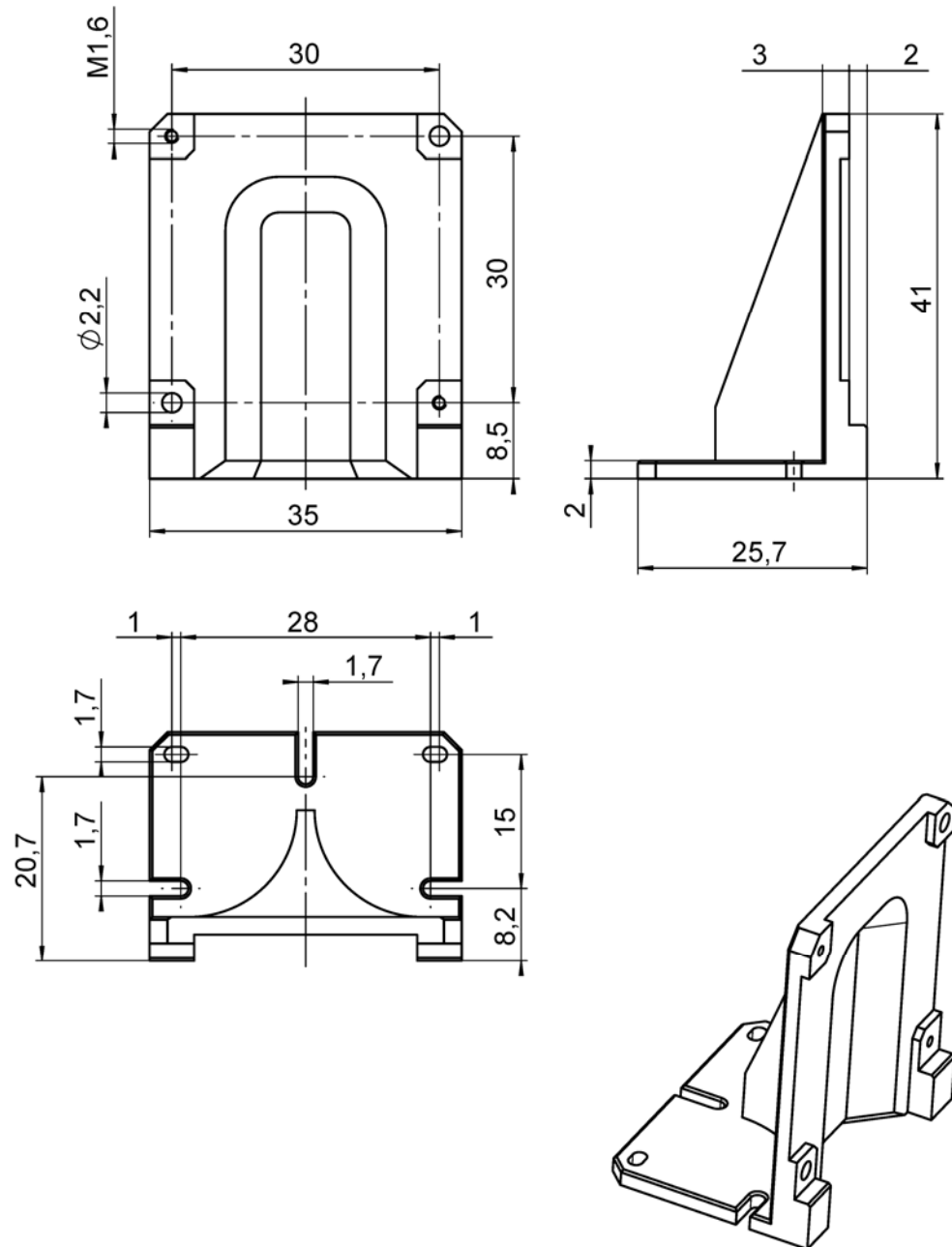


Figure 16: M-663.AV1 mounting bracket for stacking a Z system

## 11.4 Pin Assignments

**Connector: MDR14, N10214-52B2VC (3M)**

| Pin | Signal    | Function                             |
|-----|-----------|--------------------------------------|
| A1  | GND       | 0 V                                  |
| A2  | NC        | not connected                        |
| A3  | NC        | not connected                        |
| A4  | REFSWITCH | Reference switch                     |
| A5  | NC        | not connected                        |
| A6  | VDD       | +5 V                                 |
| A7  | USM_P1    | Piezo                                |
| B1  | USM_P2    | Piezo                                |
| B2  | USM_P3    | Piezo                                |
| B3  | ENCA+     | Encoder channel A, RS-422            |
| B4  | ENCA-     | Encoder channel A (inverted), RS-422 |
| B5  | ENCB+     | Encoder channel B, RS-422            |
| B6  | ENCB-     | Encoder channel B (inverted), RS-422 |
| B7  | NC        | not connected                        |

## 11.5 Suitable Drive Electronics and Controllers

For closed-loop operation of stages with PLine® piezomotor drives, you need either one piezomotor controller (which is a combination device) or drive electronics with a separate controller and suitable software. The selection of these devices depends on the type of application they are used for. We recommend that you use the combination device because you will not need a separate controller and the software will be included with the device. The table below describes the suitable drive electronics and controllers.

| Product Code | Description  |
|--------------|--|
| C-867        | <p>Piezomotor controller with drive electronics for PLine® systems<br/>(combination device)</p> <p>The C-867 piezomotor controllers/drive electronics perform the position servo-control and provide the operating voltage for the stage. Separate drive electronics is not necessary. The user adjusts the operating voltage for the stage by changing parameters in the software.</p>  |
| C-185        | <p>Analog drive electronics, bench-top with power supply. C-185 drive electronics converts an analog control signal (differential, 10 V) into the voltage which is required by the piezomotor drives. In addition to the drive electronics, a controller suitable for piezomotor drives is needed (available from a third-party supplier). This controller performs position control and provides the appropriate control signal for the drive electronics. Furthermore, the controller must be able to process the reference signals of the stage.</p> <p>The following combination is possible:</p> <ul style="list-style-type: none"> <li>▪ M-663 stage with C-185.161 drive electronics</li> </ul> |

### INFORMATION

The C-185 drive electronics must be fine-tuned with the mechanics.

- Always order mechanics and drive electronics together.
- To order, contact our customer service department (see p. 37).

## 12 Old Equipment Disposal

Since 13 August 2005, in accordance with the EU directive 2002/96/EC (WEEE), electrical and electronic equipment can no longer be disposed of in the member states of the EU with other wastes.

When disposing of your old equipment, observe the international, national and local rules and regulations.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstr. 1  
D-76228 Karlsruhe, Germany





## 13 Declaration of Conformity

### Declaration of Conformity

according to DIN EN ISO/IEC 17050:2005-01

**Manufacturer:** Physik Instrumente (PI)  
GmbH & Co. KG

**Manufacturer's  
Address:** Auf der Römerstraße 1  
D-76228 Karlsruhe,  
Germany



**The manufacturer hereby declares that the product**

**Product Name:** PLine® Linear Motor Stage

**Model Numbers:** M-663

**Product Options:** all

complies with all relevant provisions of the **Machinery Directive (2006/42/EC)**. Furthermore, it complies with all provisions of the **Low Voltage Directive (2006/95/EC)** and the **EMC Directive (2004/108/EC)**.

**The applied standards certifying the conformity are listed below.**

**Safety of Machinery:** EN 12100


**Safety (Low Voltage Directive):** EN 61010-1

**Electromagnetic Emission:** EN 61000-6-3, EN 55011


**Electromagnetic Immunity:** EN 61000-6-1

The person authorized to compile the technical file is: Bernd Philips

August 5, 2010  
Karlsruhe, Germany



Dr. Karl Spanner  
President

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